Partial and Double-differential Neutron Scattering Cross Sections from Elemental Titanium at Energies between 8 and 15 MeV

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Precise determination of neutron scattering cross sections is an important basis for improvement of existing neutron data libraries. In the energy range between 7 MeV and 14 MeV, such experimental data are sparce due to the lack of monoenergetic neutron sources. At PTB, the technique for measurement and data analysis was developed in order to fill this "data gap" with precisely determined cross sections.

The neutron scattering cross sections were obtained using time-of-flight (TOF) technique. The measured TOF spectra are simulated using an extensive Monte Carlo code which takes into consideration all relevant details of the experiment. Comparing measured TOF spectra with those simulated with iteratively improved cross sections, uncertainties below 5% can be achieved for differential partial cross sections (DX), and of about 2% for angle-integrated ones.

The method was extended to obtain also double-differential cross sections (DDX). Here, the contamination of the TOF spectra by non-monoenergetic source neutrons has to be corrected for. The parasitic neutron fractions are also simulated, and subtracted. Such simulation is successful only when the underlying data are sufficiently exact. DX from neutron libraries do not fulfil this requirement. Therefore, an additional measurement of data in the energy range below 8 MeV, the energy region of parasitic neutrons, is necessary. Here, a non-monoenergetic neutron source was applied (4-He(d,np) breakup reaction). Using such a continuous neutron source at different incident deuteron energies, the elastic DX below 8 MeV can be exactly obtained, without any approximation.

Using the technique as described above, DX and DDX from elemental titanium were determined at 11 incident neutron energies between 7.95 MeV and 14.72 MeV. As DX, elastic and inelastic (sum of the first levels around 0.9 MeV of 46-Ti and 48-Ti) cross sections were extracted. The other low-lying levels of the five titanium isotopes are superimposed such that an exact classification as partial cross sections is impossible. DDX were then determined in the emission energy range between E-max and 1.5 MeV, E-max being about 1.4 MeV lower than the incident neutron energy.

In this paper, the measurement procedure, data analysis and results will be described in more detail, a comparison of our results with existing experimental data and with neutron libraries will also be discussed.

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